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DIGESTIBILITY OF SOME BY-PRODUCT OILS.[1]

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INTRODUCTION.

In planning the experiments to determine the digestibility of edible fats it was early recognized that in order to be of greatest value the experiments with the different fats should be conducted under as nearly as possible identical conditions. Accordingly, the same experimental methods have been used throughout a series with 40 or more edible fats to which the present study is the most recent contribution. These methods were quite fully discussed in the initial report of this series.[2] As a result of this uniformity of method, the value reported for the digestibility of any individual fat discussed is directly comparable with the figures obtained for the others.

PREVIOUS INVESTIGATIONS.

Papers have appeared from time to time, reporting the digestibility of such animal fats [3] as lard; beef fat; mutton fat (kidney fat); butter; cream; chicken, goose, brisket, egg-yolk, and fish fats; goat's butter; kid, hard-palate, and horse fats; oleo oil and oleo stearin; ox-marrow, ox-tail, and turtle fats. Other papers have reported the digestibility of a large number of vegetable fats,[1] including olive, cottonseed, peanut, coconut, and sesame oils; cocoa butter; and almond, black-walnut, Brazil-nut, butternut, English-walnut, hickory-nut, pecan, corn, soy-bean, sunflower-seed, Japanese mustard-seed, rapeseed, and charlock-seed oils. The oils of such nuts as almond, black and English walnuts, Brazil nuts, and pecan are ordinarily consumed as constituents of the nuts in which they naturally occur, but with these exceptions practically all of the oils studied are commonly separated from the materials in which they naturally occur before being used for table or culinary purposes.

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[1] Prepared under the direction of C. F. Langworthy, Chief, Office of Home Economics.

[2] U. S. Dept. Agr. Bul. 310 (1915).

[3] U. S. Dept. Agr. Buls. 310 (1915), 507 (1917).

NOTE.—This bulletin records studies of the digestibility of apricot-kernel oil, cherry-kernel oil, melon-seed oil, peach-kernel oil, pumpkin-seed oil, and tomato-seed oil. It is primarily of interest to students and investigators of food problems.

POSSIBLE RECOVERY AND USE OF BY-PRODUCT OILS.

As a result of the enormously increased demand for fats and oils for both technical and edible purposes it has seemed desirable to make a study of the nature and value of fixed oils present in seeds and nuts not hitherto grown or utilized for the production of oil. For some time studies have been carried on by the Department of Agriculture to ascertain the commercial possibilities of recovering the fixed oils contained in many of the pits and seeds occurring as by-products of the fruit canning and drying industries. In 1908 Rabak[2] reported studies on the chemical and physical characteristics and the commercial uses and value of the fixed and volatile oils which may be obtained from the peach, apricot, and prune kernels. He estimates that from 210 to 420 tons of peach-kernel oil (fixed oil) and from 350 to 400 tons of apricot oil may be obtained from the by-product peach and apricot kernels produced in California alone. He also estimates that the amount of raisin-seed oil capable of being manufactured from waste raisin seed would be from 348 to 464 tons yearly.[3] He states[4] that the possible commercial utilization of the waste cherry pits of a normal year's output should yield 134 tons of fixed oil. In a recent paper the same author[5] states that the quantity of oil capable of being extracted from tomato seeds occurring as a by-product of tomatoes used for pulping purposes (catsups, etc.) would be about 343 tons annually.

From these findings it is apparent that the quantity of oil obtainable from the pits and seeds occurring as by-products is not small. In order to make the recovery of these oils a practical proposition even in those localities where the pits and seeds are to be had in sufficient quantities to obviate long hauls it apparently was necessary to find some use for the entire pit.

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[1] U. S. Dept. Agr. Buls. 505 (1917), 630 (1918), 687 (1918).

[2] U. S. Dept. Agr. Bur. Plant Indus. Bul. 133 (1908), pp. 34.

[3] U. S. Dept. Agr. Bur. Plant Indus. Bul. 276 (1913), p. 30.

[4] U. S. Dept. Agr. Bul. 350 (1916), p. 16.

[5] U. S. Dept. Agr. Bul. 632 (1917), p. 9.

The residue, commercially known as press cake, remaining after the expression of oil from peach, apricot, and cherry kernels, has much the same composition and nutritive value for stock feeding as the press cakes obtained from such oil seeds as soy bean, linseed, peanut, coconut, and cotton seed. Until very recently, however, the outer woody portion of the pits seemed to be of little value except for fuel purposes. Experimental tests and large-scale use of the carbon produced from the woody portion of fruit pits showed quite conclusively that this carbon is valuable, especially for the manufacture of gas masks. Thus, with a possible commercial demand existing for all portions of the fruit pits, it seemed desirable to give consideration to the utilization of these by-products.

While the oils obtainable from waste pits and seeds are satisfactory for a variety of technical purposes, it is of course evident that if they can be commercially prepared so that they are satisfactory for such purposes they should be available for food. Especially is this true at the present when a world-wide shortage of fats and oils exists. Accordingly, laboratory studies of the expression of oils from various kernels were made. The results of these studies showed that if care was observed both in the preparation of the pits and in the expression of oil from them a high-grade edible oil could be obtained.

If the peach, apricot, and cherry pits were allowed to stand for any length of time in the moist condition in which they were removed from the fruits, fermentation developed and the oil which was obtained was usually not suited for edible purposes. On the other hand, it was found in laboratory procedure that if the peach, apricot, and cherry kernels were dried, ground, and expressed by hydraulic pressure (i. e., "cold pressed"), the oils obtained were perfectly satisfactory for table purposes without any refining other than merely filtering. The peach, apricot, and cherry oils prepared in this laboratory by the above procedure were of a bland flavor, and when mixed with vinegar and condiments made excellent French dressing. In view of these findings it was decided to determine how well these oils are tolerated by the human body and to what extent they are digested. Accordingly, a supply of a number of oils which may be obtained from the by-products of the canning industry was secured, and the coefficients of digestibility were determined in the same manner as those of the other edible oils reported in previous publications.

DIGESTION EXPERIMENTS WITH MEN.

The subjects who assisted with this investigation were men in good health, whose ages ranged from 20 to 40 years. In order that the squad should represent an average group of persons of these ages an attempt was made to secure individuals who should represent both the active and athletic type of person and the less active type employed at a sedentary occupation. The subjects were all students with sufficient understanding of nutrition and physiology to appreciate the necessity for strict adherence to the directions given them. At the same time they were not informed as to the specific purpose of the experiments in which they were participating.

In the case of the oils here discussed the quantities available for experimental purposes were insufficient to permit as large a number of tests as it has been the policy to make in such investigations. Accordingly, only four tests were made with apricot-kernel oil, four with cherry-kernel oil, three with melon-seed oil, three with peach-kernel oil, two with pumpkin-seed oil, and three with tomato-seed oil.

The test periods were of the customary three-day or nine-meal duration, and sufficient time elapsed between test periods so that the diets did not become too monotonous. During the periods which intervened between test periods the subjects secured their meals at their boarding places, and were thus afforded considerable variety in their diet. No record was made of body weight, but accurate weighings were made of the food served, the uneaten portion of food, and the feces resulting from the test diet. Both food and feces were analyzed to determine the percentages of protein, fat, and carbohydrate digested.

The individual oil under consideration was fed in a special cornstarch blancmange flavored with caramel and vanilla to mask the nature of the oil present. This blancmange was served in conjunction with a diet containing a minimum of fat and consisting of wheat biscuit, oranges, and sugar.

APRICOT-KERNEL OIL.

Apricot oil, like many other oils obtainable from the pits of fruits, has been used little if at all in this country for edibile purposes. A study reported by Rabak[1] of the commercial possibilities of apricot-kernel oil indicates that the chemical and physical properties of this oil are quite similar to those of the more widely used oils, such as cottonseed, peanut, coconut, corn, and soy-bean oils. Tests of the digestibility of apricot oil seemed especially desirable, as no information regarding it was found in literature.

The apricot oil studied in this investigation was obtained by cold pressing dried apricot kernels secured through the courtesy of M. E. Jaffa, of the University of California. The oil so obtained was of light-yellow color and free from any marked odor or taste. It possessed the essential characteristics of a salad oil and mixed with vinegar formed a very agreeable salad dressing. In order that the coefficient of digestibility obtained should be directly comparable with those for other fats in this series, the apricot oil here used was incorporated in a blancmange rather than used in the form of a salad dressing; but there is no reason to suppose that the difference in the manner of use would make any appreciable difference in the digestibility.

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[1] U. S. Dept. Agr. Bur. Plant Indus. Bul. 133 (1908), pp. 34.

The following tables contain the essential data for interpreting the results of the digestion experiments with apricot oil:

Data of digestion experiments with apricot oil in a simple mixed diet.

Experiment, subject, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbo-hydrate.	Ash.
Experiment No. 559, subject H. R. G.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing apricot oil	1,443.0	664.5	24.4	155.3	588.0	10.8
Wheat biscuit	369.0	33.2	39.1	5.5	285.3	5.9
Fruit	442.0	384.1	3.5	.9	51.3	2.2
Sugar						
Total food consumed	2,254.0	1,081.8	67.0	161.7	924.6	18.9
Feces	82.0		24.1	8.5	43.5	5.9
Amount utilized			42.9	153.2	881.1	13.0
Digestibility of entire ration (per cent)			64.0	94.7	95.3	68.8
Estimated digestibility of oil alone (per cent)				99.7		
Experiment No. 560, subject A. J. H.:						
Blancmange containing apricot oil	1,748.0	805.0	29.5	188.1	712.3	13.1
Wheat biscuit	18.0	1.6	1.9	.3	13.9	.3
Fruit	103.0	89.5	.8	.2	12.0	.5
Sugar	32.0				32.0	
Total food consumed	1,901.0	896.1	32.2	188.6	770.2	13.9
Feces	79.0		27.3	14.6	29.8	7.3
Amount utilized			4.9	174.0	740.4	6.6
Digestibility of entire ration (per cent)			15.2	92.3	96.1	47.5
Estimated digestibility of oil alone (per cent)				96.4		
Experiment No. 561, subject P. K.:						
Blancmange containing apricot oil	2,133.0	982.3	36.0	229.5	869.2	16.0
Wheat biscuit	371.0	33.4	39.3	5.6	286.8	5.9
Fruit	714.0	620.5	5.7	1.4	82.8	3.6
Sugar	111.0				111.0	
Total food consumed	3,329.0	1,636.2	81.0	236.5	1,349.8	25.5
Feces	77.0		26.3	10.9	33.6	6.2
Amount utilized			54.7	225.6	1,316.2	19.3
Digestibility of entire ration (per cent)			67.5	95.4	97.5	75.7
Estimated digestibility of oil alone (per cent)				98.6		
Experiment No. 562, subject C. J. W.:						
Blancmange containing apricot oil	2,224.0	1,024.1	37.6	239.3	906.3	16.7
Wheat biscuit	429.0	38.6	45.5	6.4	331.6	6.9
Fruit	937.0	814.2	7.5	1.9	108.7	4.7
Sugar	72.0				72.0	
Total food consumed	3,662.0	1,876.9	90.6	247.6	1,418.6	28.3
Feces	95.0		30.5	12.2	45.3	7.0
Amount utilized			60.1	235.4	1,373.3	21.3
Digestibility of entire ration (per cent)			66.3	95.1	96.8	75.3
Estimated digestibility of oil alone (per cent)				98.8		
Average food consumed per subject per day	928.8	457.6	22.6	69.5	371.9	7.2

Summary of digestion experiments with apricot oil in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of apricot oil alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
559	H. R. G	64.0	94.7	95.3	68.8	99.7
560	A. J. H	15.2	92.3	96.1	47.5	96.4
561	P. K	67.5	95.4	97.5	75.7	98.6
562	C. J. W	66.3	95.1	96.8	75.3	98.8
Average		53.3	94.4	96.4	66.8	98.4

The coefficients of digestibility of the diet as a whole are comparable to those obtained in other tests with edible oils, being 53.3 per cent for protein, 94.4 per cent for fat, and 96.4 per cent for carbohydrate. On an average the subjects ate 23 grams of protein, 70 grams of fat, and 372 grams of carbohydrate daily, which had an energy value of 2,200 calories. The figure obtained for the digestibility of apricot oil alone, 98.4 per cent, indicates that this oil possesses a high nutritive value. In the tests referred to above, none of the subjects reported any unusual physiological conditions resulting from the ingestion of apricot oil. The results of these experiments as a whole, therefore, would seem to indicate that a high-grade cold-pressed apricot oil may be freely and safely used for edible purposes.

CHERRY-KERNEL OIL.

When cherry kernels are subjected to pressure and " cold pressed " a light-yellow, bland, fatty oil is obtained. Lewkowitsch[1] reports that in South Germany cold-pressed cherry-kernel oil is used for edible purposes. He further says that the oil expressed at higher temperature is used for soap making and illuminating purposes, but that cherry oil is not used as an adulterant of almond oil because of its tendency to become rancid.

In discussing the value and uses of cherry-kernel oil for other than edible purposes, Rabak[2] states that since this oil closely resembles almond, peach, and apricot oil it should be well adapted for use in pharmaceutical preparations.

The cherry-kernel oil studied in the experiments here reported was obtained by expression from dried cherry pits which were secured through the courtesy of a large canning establishment. The kernels were removed from the cherry pits by passing the pits through a mill having vertical grinding plates so set as to crack the pits without crushing the kernels. (The cracked pits were separated from the kernels, without crushing them, by mechanical means and finally by hand picking.) The cleaned, thoroughly dried kernels were ground (using the fine knife) with an ordinary household meat chopper. The oil was expressed from the finely cut kernels by means of a laboratory press which developed a pressure of approximately 2,700 pounds per square inch and which was secured for the purpose from the Drug Plant and Poisonous Plant Laboratories of the Bureau of Plant Industry. The oil which was obtained in this manner was free from sediment, of a light-yellow color, and possessed a bland, fatty taste. When a sample mixed with vinegar and condiments was prepared as a French dressing, its origin could not be detected by those unaware of its source, though all agreed that the dressing was unusually appetizing.

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[1] Chemical Technology and Analysis of Oils, Fats, and Waxes. London: Macmillan & Co. (Ltd.), 1909, vol. 2, p. 225.

[2] U. S. Dept. Agr. Bul. 350 (1916), pp. 8, 17.

The cherry-kernel oil was thoroughly mixed and incorporated in the usual cornstarch blancmange. The essential data resulting from the tests made with this oil are reported in the tables which follow:

Data of digestion experiments with cherry-kernel oil in a simple mixed diet.

Experiment, subject, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 673, subject A. A. F.:						
Blancmange containing cherry-kernel oil	*Grams.* 1,681.0	*Grams.* 780.0	*Grams.* 59.8	*Grams.* 157.0	*Grams.* 669.2	*Grams.* 15.0
Wheat biscuit	345.0	31.0	36.6	5.2	266.7	5.5
Fruit	850.0	738.7	6.8	1.7	98.6	4.2
Sugar	179.0				179.0	
Total food consumed	3,055.0	1,549.7	103.2	163.9	1,213.5	24.7
Feces	65.0		18.0	10.6	27.6	8.8
Amount utilized			85.2	153.3	1,185.9	15.9
Digestibility of entire ration (per cent)			82.6	93.5	97.7	64.4
Estimated digestibility of oil alone (per cent)				97.3		
Experiment No. 674, subject P. K.:						
Blancmange containing cherry-kernel oil	2,366.0	1,097.8	84.2	221.0	941.9	21.1
Wheat biscuit	304.0	27.4	32.2	4.5	235.0	4.9
Fruit	403.0	350.2	3.2	.8	46.8	2.0
Sugar	148.0				148.0	
Total food consumed	3,221.0	1,475.4	119.6	226.3	1,371.7	28.0
Feces	66.0		20.5	10.2	30.0	5.3
Amount utilized			99.1	216.1	1,341.7	22.7
Digestibility of entire ration (per cent)			82.9	95.5	97.8	81.1
Estimated digestibility of oil alone (per cent)				98.3		
Experiment No. 675, subject J. C. M.:						
Blancmange containing cherry-kernel oil	2,149.0	997.2	76.5	200.7	855.5	19.1
Wheat biscuit	282.0	25.4	29.9	4.2	218.0	4.5
Fruit	635.0	551.8	5.1	1.3	73.6	3.2
Sugar	192.0				192.0	
Total food consumed	3,258.0	1,574.4	111.5	206.8	1,339.1	26.8
Feces	76.0		22.8	9.9	35.9	7.4
Amount utilized			88.7	196.3	1,303.2	19.4
Digestibility of entire ration (per cent)			79.6	95.2	97.3	72.4
Estimated digestibility of oil alone				98.8		

Data of digestion experiments with cherry-kernel oil in a simple mixed diet—Continued.

Experiment, subject, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 676, subject A. A. R.:						
Blancmange containing cherry-kernel oil	*Grams.* 1,166.0	*Grams.* 541.0	*Grams.* 41.5	*Grams.* 108.9	*Grams.* 464.2	*Grams.* 10.4
Wheat biscuit	178.0	16.0	18.9	2.7	137.6	2.8
Fruit	1,263.0	1,097.6	10.1	2.5	146.5	6.3
Sugar	131.0				131.0	
Total food consumed	2,738.0	1,654.6	70.5	114.1	879.3	19.5
Feces	53.0		18.1	7.9	21.2	5.8
Amount utilized			52.4	106.2	858.1	13.7
Digestibility of entire ration (per cent)			74.3	93.0	97.6	70.3
Estimated digestibility of oil alone (per cent				97.4		
Average food consumed per subject per day	1,022.7	521.2	33.7	59.2	400.3	8.3

Summary of digestion experiments with cherry-kernel oil in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of cherry-kernel oil alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
673	A. A. F	82.6	93.5	97.7	64.4	97.3
674	P. K	82.9	95.5	97.8	81.1	98.3
675	J. C. M	79.6	95.2	97.3	72.4	98.8
676	A. A. R	74.3	93.0	97.6	70.3	97.4
Average		79.9	94.3	97.6	72.1	98.0

It will be noted from the above data that the diet as a whole was quite well digested, the values obtained being 79.9 per cent for protein, 94.3 per cent for fat, and 97.6 per cent for carbohydrate. On an average the subjects ate 34 grams of protein, 59 grams of fat, and 400 grams of carbohydrate, which supplied 2,270 calories of energy. No attempt was made to ascertain how much cherry-kernel oil could be eaten daily without producing a laxative effect; but, since one of the subjects ate aproximately 74 grams daily for the three-day period, it seems apparent that the limit of tolerance for this oil is in excess of this amount.

The high digestibility of cherry-kernel oil, 98 per cent, when considered in connection with the pleasing appearance and flavor of the cold-pressed oil, warrants the belief that when cherry pits are obtainable in quantity they should prove a valuable source of a high-grade culinary or table oil.

MELON-SEED OIL.

While melon (cantaloup) seeds are not available in this country in sufficient quantities to be of commercial importance as a source of oil, Lewkowitsch reports[1] that melon seeds form an article of commerce on the Slave Coast and Gold Coast of West Africa. In studies of the relative commercial value of unutilized oil-producing seeds and nuts as possible sources of oil, H. S. Bailey, oil specialist of the Bureau of Chemistry, gave some attention to this oil. A sample of cantaloup-seed oil was expressed from cleaned, dried cantaloup seed in a continuous-process-expeller type of oil press under conditions approximating those of the commercial oil mill. The cold-pressed oil which was obtained was of a light-yellow color without characteristic odor or flavor. Since this oil seemed to possess the desirable characteristics of a table oil, it was decided to determine its digestibility, and accordingly three tests were made, the results of which are reported in the following table:

Data of digestion experiments with cantaloup-seed oil in a simple mixed diet.

Experiment, subject, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 891, subject G. S. M.:						
	Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing cantaloup-seed oil	1,057.0	495.8	18.6	124.4	409.8	8.4
Wheat biscuit	120.0	10.8	12.7	1.8	92.8	1.9
Fruit	1,153.0	1,002.0	9.2	2.3	133.7	5.8
Sugar	293.0				293.0	
Total food consumed	2,623.0	1,508.6	40.5	128.5	929.3	16.1
Feces	39.0		10.3	2.9	23.5	2.3
Amount utilized			30.2	125.6	905.8	13.8
Digestibility of entire ration (per cent)			74.6	97.7	97.5	85.7
Estimated digestibility of oil alone (per cent)				100.0		
Experiment No. 892, subject M. L. M.:						
Blancmange containing cantaloup-seed oil	862.0	404.4	15.2	101.4	334.2	6.8
Wheat biscuit	231.0	20.8	24.5	3.5	178.5	3.7
Fruit	932.0	809.9	7.5	1.9	108.1	4.6
Sugar	150.0				150.0	
Total food consumed	2,175.0	1,235.1	47.2	106.8	770.8	15.1
Feces	37.0		11.6	5.9	15.2	4.3
Amount utilized			35.6	100.9	755.6	10.8
Digestibility of entire ration (per cent)			75.4	94.5	98.0	71.5
Estimated digestibility of oil alone (per cent)				97.8		
Experiment No. 893, subject W. O'C.:						
Blancmange containing cantaloup-seed oil	1,092.0	512.3	19.2	128.5	423.4	8.6
Wheat biscuit	179.0	16.1	19.0	2.7	138.4	2.8
Fruit	1,221.0	1,061.1	9.8	2.4	141.6	6.1
Sugar	528.0				528.0	
Total food consumed	3,020.0	1,589.5	48.0	133.6	1,231.4	17.5
Feces	63.0		16.1	10.5	30.6	5.8
Amount utilized			31.9	123.1	1,200.8	11.7
Digestibility of entire ration (per cent)			66.5	92.1	97.5	66.9
Estimated digestibility of oil alone (per cent)				96.7		
Average food consumed per subject per day	868.7	481.5	15.1	41.0	325.7	5.4

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[1] Chemical Technology and Analysis of Oils, Fats, and Waxes. London: Macmillan & Co. (Ltd.), 1909, vol. 2, p. 127.

Summary of digestion experiments with cantaloup-seed oil in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of cantaloup-seed oil alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
891	G. S. M.	74.6	97.7	97.5	85.7	100.0
892	M. L. M.	75.4	94.5	98.0	71.5	97.8
893	W. O'C.	66.5	92.1	97.5	66.9	96.7
Average		72.2	94.8	97.7	74.7	98.2

The value 98.2 per cent obtained for the digestibility of the cantaloup-seed oil alone indicates that this oil is very completely digested. An average of 15 grams of protein, 41 grams of fat, and 326 grams of carbohydrate, which supplied 1,730 calories, was eaten per man daily, of which 72 per cent of the protein, 95 per cent of the fat, and 98 per cent of the carbohydrate was digested, showing that the cantaloup-seed oil did not exert any unfavorable influence on the digestibility of the diet as a whole. The cantaloup-seed-oil blancmange was as palatable as the similar dishes prepared with other oils. It should be noted, however, that because of the limited amount of cantaloup-seed oil available for experimental purposes, the actual amount of blancmange eaten daily by the subjects was considerably less than in most of the experiments reported in this investigation.

The experiments here reported may, nevertheless, be considered as evidence that good quality cold-pressed cantaloup-seed oil is very satisfactory for edible purposes.

PEACH-KERNEL OIL.

The peach-kernel oil which was studied in the experiments reported below was expressed under laboratory conditions. A liberal supply of peach stones was obtained from a large eastern fruit-canning establishment. The peach stones were shipped as soon as removed from the fruit, in the moist condition, and when they arrived at the laboratory they had commenced to ferment. The stones were immediately cracked by hand and the kernels carefully separated. These were slowly but thoroughly dried, after which they were finely ground with an ordinary meat chopper. The ground kernels were subjected to hydraulic pressure and an oil of a clear pale-yellow color with an agreeable nutlike taste, resembling in physical appearance highly refined cottonseed oil, was obtained. The oil was practically free from sediment and received no treatment, other than filtering, before it was used.

Since the amount of peach-kernel oil available for experimental purposes was limited, only three tests with this oil were completed. The results which were obtained in these tests are included in the tables below:

Data of digestion experiments with peach-kernel oil in a simple mixed diet.

Experiment, subject, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 724, subject P. K.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing peach-kernel oil.	1,751.0	757.0	67.6	219.4	693.9	13.1
Wheat biscuit	278.0	25.0	29.5	4.2	214.9	4.4
Fruit	500.0	434.5	4.0	1.0	58.0	2.5
Sugar	172.0				172.0	
Total food consumed	2,701.0	1,216.5	101.1	224.6	1,138.8	20.0
Feces	82.0		8.6	17.9	48.6	6.9
Amount utilized			92.5	206.7	1,090.2	13.1
Digestibility of entire ration (per cent)			91.5	92.0	95.7	65.5
Estimated digestibility of oil alone (per cent)				95.5		
Experiment No. 725, subject J. C. M.:						
Blancmange containing peach-kernel oil.	1,743.0	753.5	67.3	218.4	690.7	13.1
Wheat biscuit	431.0	38.8	45.7	6.4	333.2	6.9
Fruit	1,177.0	1,022.8	9.4	2.4	136.5	5.9
Sugar	140.0				140.0	
Total food consumed	3,491.0	1,815.1	122.4	227.2	1,300.4	25.9
Feces	89.0		7.8	8.0	65.8	7.4
Amount utilized			114.6	219.2	1,234.6	18.5
Digestibility of entire ration (per cent)			93.6	96.5	94.9	71.4
Estimated digestibility of oil alone (per cent)				100.0		
Experiment No. 726, subject A. A. R.:						
Blancmange containing peach-kernel oil.	800.0	345.9	30.9	100.2	317.0	6.0
Wheat biscuit	391.0	35.2	41.4	5.9	302.2	6.3
Fruit	1,253.0	1,088.9	10.0	2.5	145.3	6.3
Sugar	175.0				175.0	
Total food consumed	2,619.0	1,470.0	82.3	108.6	939.5	18.6
Feces	85.0		28.0	14.1	33.5	9.4
Amount utilized			54.3	94.5	906.0	9.2
Digestibility of entire ration (per cent)			66.0	87.0	96.4	49.5
Estimated digestibility of oil alone (per cent)				94.3		
Average food consumed per subject per day.	979.0	500.2	34.0	62.3	375.4	7.2

Summary of digestion experiments with peach-kernel oil in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of peach-kernel oil alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
724	P. K.	91.5	92.0	95.7	65.5	95.5
725	J. C. M.	93.6	96.5	94.9	71.4	100.0
726	A. A. R.	66.0	87.0	96.4	49.5	94.3
Average		83.7	91.8	95.7	62.1	96.6

The results of three tests with peach-kernel oil show that the diet as a whole was well assimilated, the digestibility of the different constituents being 83.7 per cent for protein, 91.8 per cent for fat, and 95.7 per cent for carbohydrate. An average of 34 grams of protein, 62 grams of fat, and 375 grams of carbohydrate, which supplied 2,200 calories, was eaten per man daily. The subjects all reported that they felt in normal physical condition throughout the test period, which indicated that peach-kernel oil when included as a part of a simple mixed diet was well tolerated. The digestibility of peach-kernel oil alone, 96.6 per cent, may be considered as evidence that this oil is very well assimilated and would prove a valuable food oil.

PUMPKIN-SEED OIL.

The oil that is obtained by cold expression of pumpkin seeds is classified as a semidrying oil and is of a slightly greenish-yellow color. In South Russia this oil is prepared on a commercial scale by roasting the pumpkin seeds, after which the oil is hot pressed. Lewkowitsch[1] states that the hot-pressed oil is viscous, of a brownish-green color by transmitted light, and of a deep red color by reflected light. He further states that attempts to bleach and refine hot-pressed pumpkin-seed oil have not met with success.

While the amount of pumpkin canned at present is not large, both the output of the individual factories and the number of canneries packing pumpkin are increasing and the indications are that eventually the available supply of pumpkin seed will be sufficient to warrant commercial consideration.

The pumpkin-seed oil studied in the tests here reported was obtained through the courtesy of H. S. Bailey, of the Bureau of Chemistry. It was prepared by cold pressing a supply of pumpkin seeds obtained from a commercial canning establishment. It may be assumed that this oil was very nearly representative of high-grade pumpkin-seed oil of commerce. Since only a very limited supply of pumpkin-seed oil was available, only two tests were possible. The results which were obtained in these tests are reported in the tables following:

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[1] Chemical Technology and Analysis of Oils, Fats, and Waxes. London: Macmillan & Co. (Ltd.), 1909, vol. 2, p. 124.

Data of digestion experiments with pumpkin-seed oil in a simple mixed diet.

Experiment, subject, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 829, subject P. K.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing pumpkin-seed oil	1,429.0	723.2	25.1	216.4	456.4	7.9
Wheat biscuit	368.0	33.1	39.0	5.5	284.5	5.9
Fruit	318.0	276.3	2.6	.6	36.9	1.6
Sugar	236.0				236.0	
Total food consumed	2,351.0	1,032.6	66.7	222.5	1,013.8	15.4
Feces	61.0		18.2	11.1	26.6	5.1
Amount utilized			48.5	211.4	987.2	10.3
Digestibility of entire ration (per cent)			72.7	95.0	97.4	66.8
Estimated digestibility of oil alone (per cent)				97.6		
Experiment No. 830, subject G. S. M.:						
Blancmange containing pumpkin-seed oil	1,524.0	771.3	26.8	230.7	486.8	8.4
Wheat biscuit	231.0	20.8	24.5	3.5	178.5	3.7
Fruit	632.0	549.2	5.0	1.3	73.3	3.2
Sugar	445.0				445.0	
Total food consumed	2,832.0	1,341.3	56.3	235.5	1,183.6	15.3
Feces	91.0		26.6	11.9	43.2	9.3
Amount utilized			29.7	223.6	1,140.4	6.0
Digestibility of entire ration (per cent)			52.8	94.9	96.4	39.2
Estimated digestibility of oil alone (per cent)				98.7		
Average food consumed per subject per day	863.8	395.7	20.5	76.5	366.2	5.1

Summary of digestion experiments with pumpkin-seed oil in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of pumpkin-seed oil alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
829	P. K.	72.7	95.0	97.4	66.8	97.6
830	G. S. M.	52.8	94.9	96.4	39.2	98.7
Average		62.8	95.0	96.9	53.0	98.2

In the two tests reported above the subjects ate 21 grams of protein, 77 grams of fat, and 366 grams of carbohydrate, which supplied 2,235 calories of energy. Of the 76 grams of fat eaten daily 74.5 grams was pumpkin-seed oil. As they reported no laxative effects resulting from this diet it may be concluded that the limit of tolerance for pumpkin-seed oil is in excess of 75 grams daily. The diet as a whole was well assimilated, for the digestibility was found to be 62.8 per cent for protein, 95 per cent for fat, and 96.9 per cent for carbohydrate. The value 98.2 per cent for the digestibility of pumpkin-seed oil implies that this oil is well assimilated. While the supply of pumpkin-seed oil available was sufficient for only two tests, the results of these seem to justify the conclusion that pumpkin-seed oil of good quality would be a valuable food and possess a dietary value similar to that of better-known edible oils.

TOMATO-SEED OIL.

While definite figures regarding the amount of tomato seed resulting from the commercial manufacture of tomato pulp and catsup are not available, it has been estimated by Rabak[1] that approximately 1,500 tons of dry tomato seeds could be obtained annually. Dried tomato seeds contain approximately the same proportion of fixed oil as such well-known oil seeds as cotton seed, soy beans, etc. Tomato-seed oil may be obtained by either extracting or pressing the tomato seeds. When the seeds are subjected to the action of such solvents as ether or carbon tetrachlorid, a pale greenish-yellow oil is extracted. Expressed tomato-seed oil is of higher quality and usually requires less refining, but a smaller yield is obtained.

From a study of the physical and chemical characteristics of tomato-seed oil as compared with those of cottonseed, soy bean, sesame, and corn oils, it appeared to Rabak[1] that tomato-seed oil should be equally useful and applicable to the same purposes as better-known oils of commerce. Accordingly, digestion experiments were here conducted to determine the digestibility of a well-refined tomato-seed oil prepared in the Bureau of Plant Industry laboratories.

This oil, which was of a brownish-yellow color, possessed a slight but quite distinctive odor and flavor. Both the odor and flavor were very completely masked when the oil was incorporated in the usual cornstarch blancmange.

The results which were obtained in the three tests that were made of tomato-seed oil are recorded in the tables which follow:

Data of digestion experiments with tomato-seed oil in a simple mixed diet.

Experiment, subject, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 608, subject P. K.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing tomato-seed oil	2,142.0	1,110.4	38.8	194.7	704.3	93.8
Wheat biscuit	359.0	32.3	38.1	5.4	277.5	5.7
Fruit	692.0	601.3	5.5	1.4	80.3	3.5
Sugar	143.0	....	....	....	143.0	....
Total food consumed	3,336.0	1,744.0	82.4	201.5	1,205.1	103.0
Feces	79.0	....	26.1	20.9	23.3	8.7
Amount utilized	....	....	56.3	180.6	1,181.8	94.3
Digestibility of entire ration (per cent)	....	....	68.3	88.1	98.1	91.6
Estimated digestibility of oil alone (per cent)	....	....	....	93.3	....	....
Experiment No. 609, subject J. C. M.:						
Blancmange containing tomato-seed oil	1,505.0	780.2	27.2	136.8	494.9	65.9
Wheat biscuit	306.0	27.5	32.4	4.6	236.5	5.0
Fruit	1,030.0	895.1	8.2	2.1	119.5	5.1
Sugar	103.0	....	....	....	103.0	....
Total food consumed	2,944.0	1,702.8	67.8	143.5	953.9	76.0
Feces	91.0	....	28.9	12.4	41.0	8.7
Amount utilized	....	....	38.9	131.1	912.9	67.3

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[1] U. S. Dept. Agr. Bul. 632 (1917), pp. 15.

Data of digestion experiments with tomato-seed oil in a simple mixed diet—Con.

Experiment, subject, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbo-hydrate.	Ash.
Experiment No. 609, subject J. C. M.—Con.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Digestibility of entire ration (per cent)			57.4	91.4	95.7	88.6
Estimated digestibility of oil alone (per cent)				97.5		
Experiment No. 610, subject C. J. W.:						
Blancmange containing tomato-seed oil	1,960.0	1,016.1	35.5	178.2	644.4	85.8
Wheat biscuit	469.0	42.2	49.7	7.0	362.6	7.5
Fruit	746.0	648.3	6.0	1.5	86.5	3.7
Sugar	45.0				45.0	
Total food consumed	3,220.0	1,706.6	91.2	186.7	1,138.5	97.0
Feces	103.0		32.1	16.3	45.8	8.8
Amount utilized			59.1	170.4	1,092.7	88.2
Digestibility of entire ration (per cent)			64.8	91.3	96.0	90.9
Estimated digestibility of oil alone (per cent)				96.6		
Average food consumed per subject per day	1,055.6	572.6	26.8	59.1	366.4	30.7

Summary of digestion experiments with tomato-seed oil in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of tomato-seed oil alone.
		Protein.	Fat.	Carbo-hydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
608	P. K.	68.3	88.1	98.1	91.6	93.3
609	J. C. M.	57.4	91.4	95.7	88.6	97.5
610	C. J. W.	64.8	91.3	96.0	90.9	96.6
Average		63.5	90.3	96.6	90.4	95.8

In the tests with tomato-seed oil the digestibility of the diet as a whole was found to be 63.5 per cent for protein, 90.3 per cent for fat, and 96.6 per cent for carbohydrate. On an average, the subjects ate 27 grams of protein, 59 grams of fat, and 366 grams of carbohydrate, the energy value of which was 2,100 calories. The subjects ate approximately 57 grams of tomato-seed oil daily. In one instance, Experiment No. 608, subject P. K., an average of over 67 grams of fat or approximately 65 grams of tomato-seed oil was eaten daily. In all of the tests the subjects reported that they were in normal physical condition and so it may be assumed that tomato-seed oil is fairly well tolerated by the human body.

DISCUSSION.

The table beyond summarizes the results of the digestion experiments with oils expressed from apricot, cherry, and peach kernels, and from melon, pumpkin and tomato seeds. The figures reported for the digestibility of the protein, fat, and carbohydrate of the entire ration and those reported for the digestibility of the oil alone are obtained by averaging the results of the individual tests with the different oils.

Summary of digestion experiments with by-products oils.

Kind of oil.	Number of experiments.	Digestibility of entire ration.			Average amount of oil eaten per man per day.	Digestibility of oil alone.
		Protein.	Fat.	Carbohydrate.		
		Per cent.	*Per cent.*	*Per cent.*	*Grams.*	*Per cent.*
Apricot-kernel oil	4	53.3	94.4	96.4	68	98.4
Cherry-kernel oil	4	79.9	94.3	97.6	57	98.0
Melon-seed oil	3	72.2	94.8	97.7	40	98.2
Peach-kernel oil	3	83.7	91.8	95.6	60	96.6
Pumpkin-seed oil	2	62.8	95.0	96.9	75	98.2
Tomato-seed oil	3	63.5	90.3	96.6	57	95.8

The amount of oil consumed in the above experiments was not as large as in the early experiments of this series, but, as noted on page 4, this was due to an inadequate supply of the oils under consideration and not to the quality of the oil. The small supply of oils also limited the number of experiments which could be made.

No attempt was made to determine the upper limit of tolerance of these oils, but since in these tests as much as approximately 80 grams of apricot-kernel oil, 74 grams of cherry-kernel oil, 43 grams of melon (cantaloup) seed oil, 73 grams of peach-kernel oil, 77 grams of pumpkin-seed oil, and 65 grams of tomato-seed oil was eaten by one of the subjects for three successive days without physiological disturbances being noted, it is safe to conclude that the limit of tolerance is in excess of these amounts.

The coefficients of digestibility of the by-products oils, 98.4 per cent for apricot-kernel oil, 98 per cent for cherry-kernel oil, 98.2 per cent for melon (cantaloup) seed oil, 96.6 per cent for peach-kernel oil, 98.2 per cent for pumpkin-seed oil, and 95.8 per cent for tomato-seed oil indicates that these oils are very well assimilated by the body and possess a nutritive value equal to that of other better known edible oils, such as cottonseed, corn, peanut, coconut, soybean, and olive oils. In general the experiments here reported indicate that as far as tolerance and assimilation are concerned apricot, cherry, and peach kernel, and melon (cantaloup), pumpkin, and tomato-seed oils, which at present are practically unutilized, are wholesome, nutritious foods, and should prove satisfactory for edible purposes.

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